DEDUCTIBLES IN INDUSTRIAL FIRE INSURANCE

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1. INTRODUCTION

In recent times, the subject of deductibles in Industrial Fire insurance has gained significance to an increasing extent. In fact, up to a short time ago it was by no means common to apply deductibles in Industrial Fire insurance in Europe. The situation is entirely different in the USA where deductibles are the usual thing and are even obligatory with individual risk categories (e.g. petroleum refineries), hazards (e.g. explosion), or special types of companies (e.g. factory mutuals).

Today, however, there is a definite increase in the demand for deductibles in Industrial Fire insurance in Europe, too.

This trend may be explained by the fact that in order to reorganize their business successfully, insurers have been forced to increase their premiums by a considerable amount. It seems to be an unwritten law that when premiums in general are increased considerably, the point will some time or other be reached when the insured do not accept any further premium increases. Thus, even if such increases are completely justified in a view of claims experience, the insured will demand that premiums are reduced either by the insurer granting rebates for appropriate loss prevention measures or by the introduction of deductibles. In the USA, for example, such a situation arose around 1960 when considerable premium increases very quickly led to the introduction of substantial deductibles in Industrial business. In some European countries we are currently experiencing a similar development.

Why are deductibles introduced and what purpose do they have?

When introducing or propagating deductibles, insurers may have various objectives. Basically, however, it is hoped that when a deductible is introduced the moral hazard involved will be improved since in such a case the insured will show greater interest in loss prevention and loss reduction. After all, whenever a loss does occur under a policy with a deductible, the insured will have to bear part of the financial burden himself.

Another very important point is that when a deductible is applied, the insurer will not have to settle small losses any more—which obviously relieves him of a considerable amount of work. One must therefore appreciate that the "value" of a deductible cannot only be measured in terms of the amount involved. Rather, one has to make allowance for the settlement expenditure saved by the fact that the insurer is not liable for minor losses. A further advantage is that if a deductible is applied without a premium reduction, it can be used to improve the structure of under-rated risks, as in such cases the deductible constitutes an indirect premium increase.

On the other hand, the advantage offered to the insured is that the premium he must pay to obtain insurance coverage is reduced. Together with the policy of granting rebates to the insured whenever he takes effective loss prevention measures, deductibles are therefore suitable for helping an insurer keep his market and prevent good risks from moving over to outsider markets from the local market. Similarly, by avoiding premium increases through the introduction of deductibles, the insurer can keep his business attractive for the policyholder, thus preventing any trends towards self-insurance. Finally, it should also be considered that without deductibles, it would be entirely impossible in some cases to cover severe risks.

2. Definition of a Deductible and the Difference Between Deductibles and Excess of Loss Insurance

A deductible can be defined as the participation of the insured in a loss up to a certain limit agreed on in advance.

Although this definition is very closely related to the definition of Excess of Loss insurance, the basic difference between the two is that Excess of Loss insurance is usually concluded on a first loss basis where the sum insured does not fully correspond to the value of the risk, whereas in the case of a deductible the traditional concept of full value insurance with its under-insurance clauses remains unaffected.

Speaking of deductibles as such, we may basically distinguish between amount deductibles and time deductibles. Referring to amount deductibles first of all, the most important category we have here is that of the so-called "pure" deductible where the insurer does not provide any indemnification at all for losses below the amount agreed on, while when indemnifying losses exceeding that amount, he will be responsible for the claim minus the deductible amount. When applying another kind of deductible, the so-called franchise, the insurer is required to indemnify any losses exceeding the agreed limit in full (i.e. he cannot deduct the insured's share), while the insured is responsible for any losses lower than the amount agreed on. The reason why such franchises are not as common as "pure" deductibles is most probably because policyholders always feel rather annoyed when they have to pay losses just below the fixed amount. The situation is similar when one applies the so-called disappearing deductible which is a kind of combination of a "pure" deductible and a franchise. The special characteristic of this disappearing franchise is that here the insured is liable for all losses up to the amount agreed on (which makes this the same as a "pure" deductible), while the insured's share is reduced as the amount of the claim increases so that when a certain limit is reached, the insured does not have to pay anything at all. It can be seen, therefore, that of the various kinds of amount deductibles, the deductible as such is the easiest to use. Compared with a franchise, it offers the advantage of being non-manipulatable, so that indemnification does not depend on whether a loss has exceeded the amount fixed or not.

When applying a time deductible, the deductible is defined in units of time. It is obvious therefore that such deductibles are only possible with an insurance where a loss occurs over a certain period of time and is not an instantaneous event. Thus, a time deductible is quite suitable in Fire Loss of Profits insurance. When applying a time deductible, we must again distinguish between two different types: First of all there is the "pure" time deductible as such where the insured is responsible for that share of a loss constituted by the period agreed on, while secondly we also have proportionate time deductibles where the insured pays a certain percentage in the overall loss resulting from the ratio between the time of the deductible and the duration of the loss as a whole. As proportionate time deductibles cannot be manipulated in any way, they appear preferable to standard time deductibles where the insured has the possibility in some cases of limiting the amount of a claim for, say, the first three days, thus increasing it for the following period and manipulating loss development.

As there are still considerable difficulties in calculating rebates for time deductibles, we shall confine ourselves to "pure" amount deductibles in the following.

3. Rebate Calculation With Deductibles

Assuming that the basic premium provided for in the tariff is correct, the question of calculating the rebate is of first and foremost importance when introducing a deductible. With this in mind, it should therefore be noted that the gross premium charged by the insurer is made up of the following components:

a) the risk premium required for covering claims expenditure on the basis of the equivalence principle;
b) the cost surcharges (and here it is sufficient in the present context to distinguish between the cost of claims settlement and the cost items which are dependent and independent of the premium); and
c) the profit margin.

By introducing a deductible, three factors in this calculation model are influenced: the risk premium, the costs for settling claims, and the costs which are a function of the premium.

In the following, I would therefore like to examine these three factors in greater detail.

3.1. *Risk premium*

3.1.1. Calculation of the loss elimination ratio

The degree to which the risk premium can be reduced when a deductible is introduced depends basically on the so-called loss elimination ratio. This is the factor which indicates which percentage in claims expenditure—in terms of overall claims volume—the insurer is able to save by introducing the deductible. The loss elimination ratio, which shall here be referred to as a, can be determined as soon as the distribution of claim amount is known:

$$a = \frac{\int_0^A x f(x)\,dx + A \int_A^\infty f(x)\,dx}{\int_0^\infty x\,f(x)\,dx}. \tag{1}$$

Note: a = loss elimination ratio
A = deductible
$f(x)$ = distribution of claim amount X

It is assumed in this formula (1) that the amount of any individual loss is independent of claim frequency (i.e. the number of claims related to the number of risks observed during a given period).

Up to a short time ago, it was hardly possible in Germany to obtain any representative statistics showing the distribution of claim amounts. It must therefore be appreciated that a number of major Industrial Fire insurers in Germany have participated in a special statistical survey on the basis of which all risks and claims prevailing in some selected fields of industry have been compiled over a number of years. In so doing, information has been provided on the sums insured, PMLs, and premiums as far as the relevant risks are concerned, while at the same time code figures have been determined in accordance with the breakdown of the German Fire tariff into classes of risks. The overall objective in this venture was to provide a complete survey of the each individual risk and not just a study of overall treaties. Losses were then registered separately on the basis of the claim amounts for each individual risk. This statistical survey has been provided for Fire and Fire Loss of Profits separately.

When selecting the individual fields of industry to be included in this investigation, it was decided to attach special importance to those risk categories which, according to German statistics, are characterized by considerable differences in terms of claim frequency and average claim amounts. This was done because it can be assumed that the loss elimination ratio depends to a considerable extent on these two factors of claim frequency and average claim amounts. A first analysis of the material obtained has indicated as an initial result that the distribution of claims may be approximated by using a log-normal distribution. This applies particularly to low claim amounts. On the basis of a logarithmic probability paper, Fig. 1 provides an example of such an approximation by showing the values obtained for Fire and Fire Loss of Profits for all of the statistical material (i.e. not broken down according to risk categories).

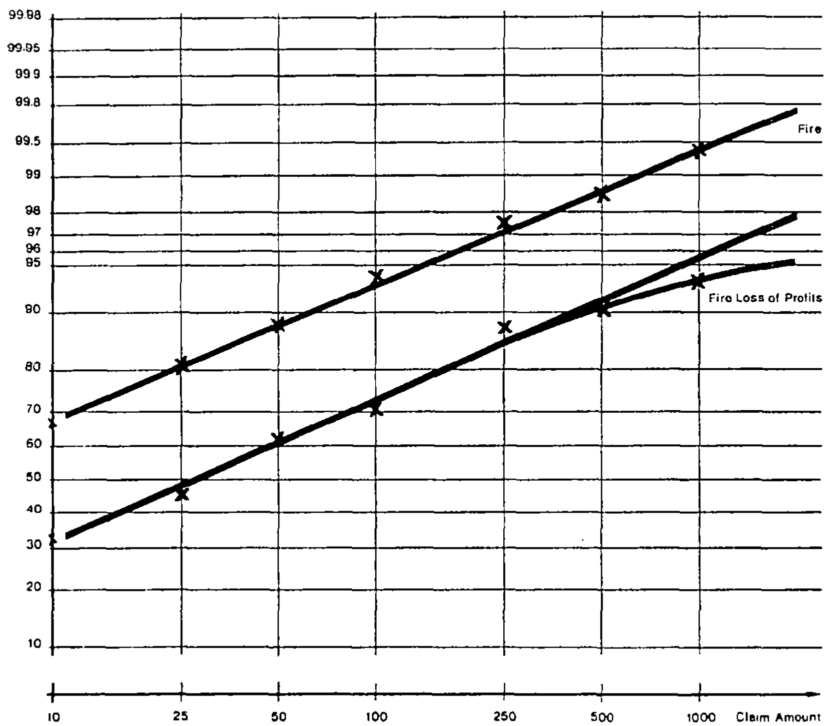

Fig. 1. Distribution of claim amounts in Industrial Fire and FLoP.

As is to be expected, the χ^2 test indicates that the hypothesis that the claim distribution is a log-normal distribution may not be rejected with a statistical reliability of 90%. Also, this result ties up very well with the observations made by G. Ferrara (see References [1]) who has shown on the basis of material compiled in Italy that claims distribution can be approximated quite effectively by way of a log-normal distribution. (It should nevertheless be noted at this point that the material compiled by G. Ferrara is representative of claim amounts far lower than the claim amounts in the material compiled in Germany.)

If, therefore, we state on the basis of equation (1)

$$f(x) = \frac{\log c}{\sqrt{2\pi}\sigma} \frac{1}{x} e^{-\frac{(\log x - \xi)^2}{2\sigma^2}} \qquad (2)$$

with the expected value $E(\log X) = \xi$ and the variance $D^2(\log X) = \sigma^2$, the following two integrals must be solved:

$$I_1(G) = \frac{\log e}{\sqrt{2\pi}\sigma} \int_0^G e^{-\frac{(\log x - \xi)^2}{2\sigma^2}} dx$$

$$I_2(A) = A \frac{\log e}{\sqrt{2\pi}\sigma} \int_A^\infty \frac{1}{x} e^{-\frac{(\log x - \xi)^2}{2\sigma^2}} dx$$

By way of some substitutions, it can be shown that

$$I_1(G) = e^{\frac{\sigma^2(\ln 10)^2 + 2\xi \ln 10}{2}} \cdot \Phi\left(\frac{\log G - \xi}{\sigma} - \sigma \ln 10\right)$$

and

$$I_2(A) = A\left(1 - \Phi\left(\frac{\log A - \xi}{\sigma}\right)\right)$$

Here, Φ is the distribution function of the (0.1) normal distribution:

$$\Phi(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-\frac{t^2}{2}} dt$$

We then obtain the following equation for the loss elimination ratio a:

$$a(A) = \Phi\left(\frac{\log A - \xi}{\sigma} - \sigma \ln 10\right) + \frac{A\left(1 - \Phi\left(\frac{\log A - \xi}{\sigma}\right)\right)}{e^{\frac{1}{2}\sigma^2(\ln 10)^2 + \xi \ln 10}} \qquad (3)$$

It is obvious of course that the loss elimination ratio determined by way of these equations cannot be applied to all risk categories. In fact, even within one and the same class of risk, we must distinguish in terms of rebate calculations between large and small risks considering that if one applies a deductible of DM 100,000.— for a small object insured, most losses will not have to be passed on to the insurer, whereas if the same deductible is applied to a large object in the same class of risk, it might only cover small partial losses. In order to calculate a suitable deductible rebate, the insurer must determine the loss elimination ratio on the basis of homogeneous classes of risk—homogeneous not only in terms of the type of risk involved, but also in terms of risk magnitude. This is precisely where the problem arises in Industrial Fire insurance, where it is extremely difficult to form homogeneous risk classes in the way just mentioned, particularly considering that the risk classes obtained must be sufficiently reliable statistically in spite of the considerable fluctuations to be expected within the framework of overall claims experience. In the following it shall therefore be attempted to show which individual factors in the material available were found to definitely have an influence on the loss elimination ratio, using statistical fitting methods.

3.1.2 Dependence of the loss elimination ratio on the absolute amount of the deductible.

Fig. 2 shows how the loss elimination ratio increases in Industrial Fire and FLoP as the deductible (expressed in DM) of the overall material compiled increases.

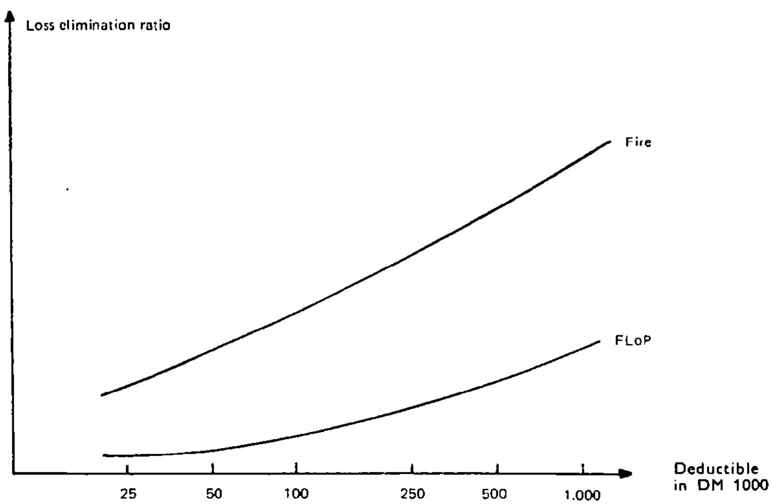

Fig. 2. Dependence of the loss elimination ratio on the absolute amount of the deductible.

This graph shows that in FLoP, the rebate granted to the insured in return for the same deductible amount must be much lower than in Fire. This situation is easy to explain:

In FLoP, the average claim is much greater than in Fire so that most FLoP claims exceed the deductible agreed upon quite considerably. The result of this naturally is that the deductible only suffices for a small percentage of claims.

Among the statistical material available, there were relatively few large losses with a claim amount of more than DM 1 million, even though experience shows that in Germany such losses are by no means infrequent and in fact constitute the major proportion of the total claims expenditure incurred by German Industrial Fire insurers. This obviously means that as soon as one is confronted with losses of such important magnitude, the statistical reliability of the material analyzed is not very good. For this reason it may be that the log-normal distribution derived from the statistical material will decrease to zero too quickly for high claim amounts, the result of this being that the insurer will underestimate the probability of large losses. This drawback is already made evident by Fig. 1 where with the higher claim amounts in FLoP the empirically determined figures cannot be approximated so accurately with the log-normal distribution. When calculating rebates to be granted to the insured in return for deductibles, this would mean that on the basis of the log-normal distribution the loss elimination ratio would be overestimated, the rebate granted thus being too high. It is a well-known fact that as soon as large losses are considered, the Pareto distribution in Fire insurance provides a much better approximation of the statistical material (see [2] and [3]), whereas of course the Pareto distribution is not suitable for describing the claim distribution for small claims this being the claim category which is also important when applying a deductible. It can be shown that as far as large claims are concerned, a good approximation can be reached by applying the Pareto distribution. With this in mind, it is perhaps advantageous to write the claim distribution $f(x)$ for the purpose of calculating the loss elimination ratio in the following manner:

$$f(x) = \begin{cases} \dfrac{c \log e}{\sqrt{2\pi}\,\sigma x}\, e^{-\frac{(\log x - \xi)^2}{2\sigma^2}} & \text{for } x \leq B \\ d x^{-\alpha} & \text{for } x > B \end{cases} \qquad (4)$$

By suitable selection of the constants to be applied in this equation, we can reach a standardization so that $\int_0^\infty f(x)\,dx = 1$. In addition, the distribution density should be continuous at point B. By introducing the claim distribution according to (4), the formula for the loss elimination ratio becomes somewhat more complicated.

Assuming for example that $B > A$ and $\alpha > 2$, we then obtain

$$a(A) = \frac{\hat{E}\,\Phi\left(\frac{\log A - \xi}{\sigma} - \sigma \ln 10\right) + cA\left(\Phi\left(\frac{\log B - \xi}{\sigma}\right) - \Phi\left(\frac{\log A - \xi}{\sigma}\right)\right) + \frac{Ad}{\alpha - 1} B^{-\alpha+1}}{\hat{E}\,\Phi\left(\frac{\log B - \xi}{\sigma} - \sigma \ln 10\right) + \frac{d}{\alpha - 2} B^{-\alpha+2}} \tag{5}$$

with

$$\hat{E} = c\, e^{\xi \ln 10 + \frac{1}{2}\sigma^2 (\ln 10)^2}$$

If B is much larger than the deductible, it is quite sufficient when calculating the rebate to estimate the risk premium share for losses larger than B. In the rebate calculation, the loss elimination ratio is then corrected accordingly by applying it not to the entire risk premium, but rather to a risk premium which has been reduced correspondingly. This procedure would be approximately in line with the concept developed by Mr. Thomazin (see [7]), who splits up the risk premium into a basic portion for covering small and medium-sized losses while applying a loading for large losses, such loadings increasing with the size of the risk. When introducing deductibles, Mr. Thomazin then only wants to grant a premium rebate for the basic premium and not for the loading mentioned.

3.1.3 Dependence of the loss elimination ratio on the individual branches of industry

The studies specified in the foregoing have been repeated for the individual branches of industry. In so doing it was found that when applying a fixed deductible, the loss elimination ratio obtained differs to a certain extent from one branch to another. In other words, the claim distribution starts to take effect at different points.

It is nevertheless advisable to arrange these individual branches of industry in groups where the effect is more or less similar, simply because otherwise the scales for rebates would become too complicated and comprehensive. In the case of the risks studied and evaluated, it was possible to form one group containing the steel and iron industry, the automobile industry, the electrical industry and the chemical industry. Another group is constituted by oil refineries and the chipboard industry where a particularly large number of major and total losses may be expected and where partial damage is of secondary significance only. Applying the same deductible, the loss elimination ratio to be obtained here is only about one-third to one-half of the ratio obtainable in the above-mentioned risk categories. This shows quite clearly that when granting rebates, we must distinguish carefully between risks susceptible to large losses to a considerable extent, and risks where the chance of a large loss is not so great.

3.1.4 Dependence of the loss elimination ratio on the PML

It has already been pointed out that the loss elimination ratio does not only depend on the absolute amount of the deductible granted, but also on the size of the risk. The most objective criterion for assessing the size of a risk is of course the sum insured of the individual complex. However, as it was not possible to the full extent with the statistical material studied to split up the figures shown in each treaty according to the individual complex, it was decided to apply the PML for the purpose of determining the "size of a risk", even though we were naturally aware of the possibility that the PML is not fixed properly. We felt that the possibility of error resulting from this would be within acceptable limits, provided risks with a relatively wide PML span would be put into one group. It was then found that if the deductible stays the same, the loss elimination ratio will decrease when the PML increases (see Fig. 3 where the step-function of the loss elimination ratio we obtained first has been fitted into a curve). It is nevertheless interesting to note that this dependence of the loss elimination ratio on the PML was only found in risk groups with a comparable claim ratio (= claims in per cent of the premium) and thus having similar claim experience. First of all, this dependence on the PML had been covered up completely by the opposite dependence of the loss elimination ratio on claim experience (see 3.1.5).

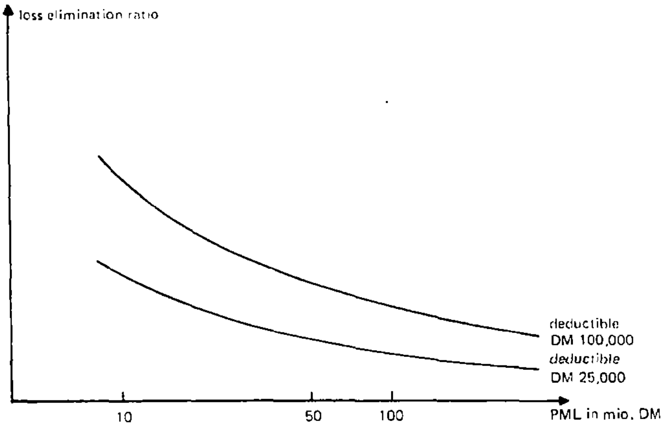

Fig. 3. Dependence of the loss elimination ratio on the PML.

One may say that approximately the loss elimination ratio corresponding to a deductible of the amount A is a function of the size of a risk, as is shown by the following equation:

$$a(A) = g(A) \cdot (\log PML)^{-\beta}, \quad \beta > 0$$

Here, $g(A)$ is a factor which depends on the general level of the loss elimination ratio of the deductible A.

3.1.5 Dependence of the loss elimination ratio on claim experience

We have found that the loss elimination ratio depends basically on the claim ratio, i.e. on claim experience. The loss elimination ratio obtained in treaties with favourable claim ratios is much higher than that obtained in treaties with unfavourable claim ratios. On the other hand, however, it must be realized that if treaties from the individual branches of industry were only to be grouped on the basis of the claim ratio criterion for each individual treaty, this would constitute an extreme act of selection as in this case a treaty will very quickly become a "bad" treaty as soon as losses start to occur.

The same characteristic as just described can however also be observed if the criterion of "good" and "bad" claim experience is related not to individual risks, but to individual branches of industry. This can be explained by the fact that in treaties and branches of industry with good claim experience and thus with a low claim ratio there will still be a number of losses, but the size of those losses and thus the average loss degree has proved to be low. This in turn means that in the case of such risks the deductible can absorb a larger proportion of claims than in the case of risks with a high claim degree.

3.1.6 The problem of anti-selection

The situation just described now brings us to one of the most important points in this discussion on deductibles, namely to the problem of anti-selection. If deductibles are granted without proper supervision in return for a rebate, there may be a danger of anti-selection by the policyholders which is basically due to the heterogeneity of risks within the same risk and rating group. Of course, it is quite obvious that in practice this heterogeneity can never be avoided completely. Therefore there will be a danger that policyholders who generally have a bad claim record will not be interested in obtaining a deductible while policyholders with a good claim record will naturally want to have a deductible. In an extreme case, this would mean that the insurer would be deprived of a considerable amount of the premium by granting deductibles for treaties that would hardly involve any claim expenditure anyway, while on the other hand he would have to indemnify just about the same losses in the case of bad risks where the insured is not interested in obtaining a deductible. This shows quite clearly that the rebates actually granted must be lower than the rebates originally calculated on the basis of the claim distribution observed in a heterogeneous class of risk.

As the problem of anti-selection results mainly from the fact that the same average premium has to be paid by both "good" and "bad" risks within the same class of risks, the danger of anti-selection will of course be much less if an experience rating is provided for in the underlying tariff as in this way the risks involved can be artificially made a little more homogeneous.

When calculating rebates, it must therefore be considered in this context whether and to what extent the rating applied is already based on experience rating. In addition, problems relating to the credibility theory must also be considered, i.e. in how far the claim experience of one individual treaty can be regarded as statistically reliable within a group of heterogeneous risks. In terms of absolute numbers, it is nevertheless difficult to cope with the problem of anti-selection, particularly considering that this problem relates to the question of moral hazard. It is obvious, therefore, that careful underwriting can contribute considerably to solving this problem. In so doing, the claim experience so far and above all claim frequency and the average claim amount may provide very important assistance in appreciating the danger of anti-selection. For the reasons already mentioned it is therefore essential not to specify rigid rebate rates, but rather to use rebate band-widths for underwriting purposes.

Mathematical model investigations can of course be very helpful in determining these rebate band-widths. In this context, I would like to refer to the work done by E. Neuburger (see [4]), who as far as I know was the first to develop a mathematical model with the help of which the effects of anti-selection can be assessed. In his work, Neuburger assumes that the portfolio involved is heterogeneous and can be split up into two more homogeneous classes of risk; homogeneous in that both of these classes have a different average claim degree, i.e. the average claim amount per loss occurrence related to the sum insured (in practice, treaties with an average claim degree of $\leq d$ are grouped under class 1, while treaties with an average claim degree of $> d$ come under class 2). In addition, it is also necessary to know, or at least estimate, the distribution of claim degrees in the two classes of risk. By proceeding on the basis of different assumptions about the number of treaties in the two classes of risk and the number of treaties in each class which take a deductible, one can study the effects of anti-selection. If all the insured in the class with the lower average claim degree then take treaties with a deductible while all the insured in the class with the higher claim degree have treaties without a deductible, we have the case of excessive anti-selection.

3.2. *The influence of the deductible on costs*

When calculating the loss elimination ratio, we know to what extent the risk premium may be reduced by applying a deductible.